

# A Review of the Genus *Kaiparathina* Laws, 1941 (Mollusca: Gastropoda: Trochoidea)

by

BRUCE A. MARSHALL

Museum of New Zealand Te Papa Tongarewa, P.O. Box 467, Wellington, New Zealand

**Abstract.** The genus *Kaiparathina* Laws, 1941, is referred to the trochid subfamily Margaritinae in a new tribe, **Kaiparathinini**. The type species of *Kaiparathina*, *K. praecellens* Laws, 1941 (Early Miocene, New Zealand) is illustrated, *Calliotrochus navakaensis* Ladd, 1982 (Pleistocene, Vanuatu) is referred to the genus, and the following new Recent species are described: *K. boucheti* and *K. vaubani* (New Caledonia), *K. coriolis* (northern Lord Howe Rise), *K. fasciata* (southern Norfolk Ridge), *K. daedala* (Réunion). *Kaiparathina senex* sp. nov. is based on a specimen from the Late Paleocene-Early Eocene of the Chatham Islands, New Zealand.

*Kaiparathina* species have an extremely distinctive radular morphology and are unique among archaeogastropods in having large, clearly delineated zones of unknown function on each side between the epipodial fringe and the sole. They are evidently sponge-feeders.

## INTRODUCTION

*Kaiparathina* Laws, 1941, was proposed for a distinctive gastropod (*K. praecellens* Laws, 1941) from the richly fossiliferous Early Miocene beds at Pakaurangi Point, Kaipara Harbour, northern New Zealand. Although LAWS (1941) did not specifically refer *Kaiparathina* to any family, the bestowed name and comparative remarks clearly indicate that he considered it to belong to the Janthinidae. BEU (1973) subsequently noted that the type species has a nacreous layer and thus referred it to Trochidae. The present contribution was initiated when I realized that *Calliotrochus navakaensis* Ladd, 1982, and some undescribed Recent species belong in *Kaiparathina*. Recent *Kaiparathina* species occur in the tropical and subtropical Indo-West Pacific on or near rocky substrata at 133–610 m depth (living specimens from rocky ground at 210–610 m).

Abbreviations: AMS—Australian Museum, Sydney; AUG—Auckland University Geology Department; BMNH—The Natural History Museum, London; LACM—Los Angeles County Museum of Natural History; MNHN—Museum National d'Histoire Naturelle, Paris; MNZ—Museum of New Zealand, Wellington; NMP—Natal Museum, Pietermaritzburg; NZGS—Institute of Geological and Nuclear Sciences, Lower Hutt; USNM—National Museum of Natural History, Washington D.C.

## SYSTEMATIC TREATMENT

Order Archaeogastropoda Thiele, 1925

Suborder Vetigastropoda Salvini-Plawen, 1980

Superfamily TROCHOIDEA Rafinesque, 1815

Family TROCHIDAE Rafinesque, 1815

Subfamily MARGARITINAE Stoliczka, 1868

Tribe **Kaiparathinini** Marshall, new

**Distribution:** Late Paleocene-Recent, tropical and subtropical southwest Pacific and Réunion.

**Diagnosis:** Shell similar to those of Margaritinae, anomphalous, with peripheral keel and sigmoidal collabral growth lines on base, spirally sculptured. Snout fringed with papillate processes, prominent propodial horns, no cephalic lappets. Large, swollen, clearly delineated, sub-circular anterolateral structures on each side of foot between epipodial fringe and sole. Ctenidium bipectinate, afferent membrane short. Central and lateral radular teeth strongly hooded and flanged, central tooth exceptionally large; shafts of all but innermost and outermost marginal teeth incompletely separated; innermost marginal not enlarged.

**Description:** Shell conispiral, up to about 10 mm high, thin to rather thick, anomphalous, glossy, nacreous within,

teleoconch frequently with supramedian and peripheral rows of spots and/or wavy axial lines. Protoconch smooth apart from few fine spiral threads. Teleoconch whorls all convex or becoming almost flat, periphery weakly or strongly angulate, base weakly convex or more or less flat; periphery with rounded spiral cord; all spire whorls or first 2 spire whorls spirally lirate; base with or without spiral lirae; collabral growth lines weakly sigmoidal on spire, more strongly sigmoidal on base. Aperture subcircular, peristome discontinuous. Operculum chitinous, multispiral, thin, growing edge short. Animal with prominent papillate processes at broad snout edge. Large swollen, subcircular anterolateral structures on each side of foot between non-digitate epipodial fringe and sole; each anterolateral structure bounded by low ridge, comprising crowded, minutely pustulose, hemispherical structures (histology and function unknown). Epipodial tentacles of moderate size, minutely and densely papillate, numbering 3 on each side; no cephalic lappets, neck lobes simple; prominent propodial horns. Ctenidium large, bipectinate, free tip long and tapered, leaflets on right side thicker, afferent membrane short. Radular teeth in about 40 cross rows, central field evenly curved; central and lateral teeth stout, with angulate, strongly hooded cutting areas, shafts laterally flanged and grooved, faces thickened, central tooth relatively large; lateral teeth multiplying by progressive in-column morphological transformation of marginal teeth into a late stage of ontogenesis, smoothly enlarging outwards, 4–9 pairs per cross row at maturity; no latero-marginal plates; marginal fields narrow, teeth numerous, morphologically grading rather smoothly into laterals, slender, tips rounded and finely serrate, outermost marginal much broader than inner marginals, shafts of all but innermost and outermost teeth incompletely separated. Jaws present.

**Remarks:** Although undoubtedly trochoidean, species of *Kaiparathina* cannot be satisfactorily grouped into any of the known families or subfamilies as defined by HICKMAN & MCLEAN (1990). Among Trochoidea, the topographically complex, strongly hooded, laterally interlocking teeth of the central radular field are most similar to those in adult Eucyclinae, especially Calliotropini (HICKMAN & MCLEAN, 1990:figs. 43, 47), the radula differing principally by having a relatively larger central tooth, and incompletely separated marginal teeth with broad comblike cutting areas. The ctenidium most closely resembles those in Eucyclinae, Margaritinae, and Tegulinae, which differ markedly from those of other trochid subfamilies (HICKMAN & MCLEAN, 1990). This ctenidial type—fully bipectinate with a long free tip and a short afferent membrane—is characteristic of trochoideans with particularly long fossil records, and has been interpreted by HICKMAN & MCLEAN (1990) as a plesiomorphy. *Kaiparathina* seems unlikely to be closely related to Eucyclinae, in which the shell sculpture is predominantly axial, especially on the early teleoconch whorls, while the heavy shells of the lit-

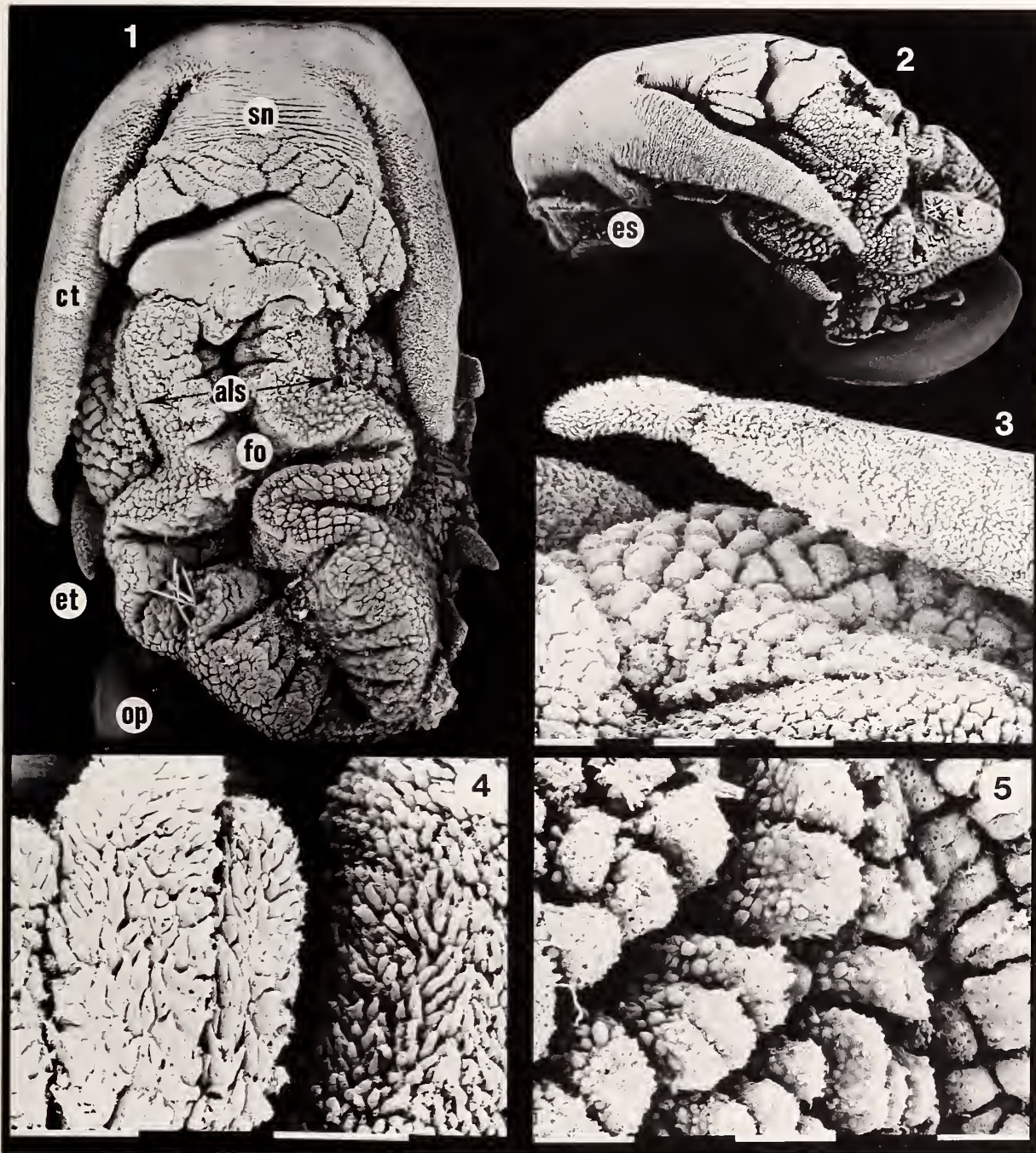
toral or shallow sublittoral Tegulinae are entirely dissimilar. Among the three subfamilies, shell morphology most closely approaches that of Margaritinae, in which spiral sculpture is also predominant, if not on all teleoconch whorls then usually on the earliest ones. Although probably independently derived, some aspects of head-foot morphology approach those exhibited by *Gaza superba* (Dall, 1881) (Margaritinae, Gazini) in which the edge of the oral shield is digitate, and the foot has anterolateral projections. *Gaza superba* is, however, strongly dissimilar in size and in shell and adult radular morphology, and in other aspects of head-foot morphology (HICKMAN & MCLEAN, 1990).

The central and lateral radular teeth of all known adult margaritines differ from those in *Kaiparathina* by having strongly outwardly bowed shafts, broader and flatter shaft faces, and non-hooded cutting areas (HICKMAN & MCLEAN, 1990:figs. 50, 53). As shown by WARÉN (1990), trochoidean radulae undergo often profound progressive morphological transformations during ontogenesis, and the radulae of most juvenile trochoideans (with the notable exception of calliostomatids) are at first essentially similar to each other. For this reason it is unnecessary to invoke progressive “horizontal” evolutionary transformations to derive divergent radular morphologies from one another. Since adult radulae of *Kaiparathina* species are not unlike those of juvenile trochoideans in general (WARÉN, 1990), it would seem that somatic development of their radulae is retarded (paedomorphosis) relative to that in Margaritinae, Eucyclinae, and Tegulinae. This contention is supported by the relatively narrow marginal fields with relatively low numbers of incompletely separated teeth.

Accordingly, and despite the differences in adult radulae, I conclude that *Kaiparathina* and Margaritinae are related. While this group may well prove worthy of subfamilial status on the basis of additional data (e.g., anatomical and molecular), for the present I regard it as a clade within Margaritinae, for which the informal tribal name **Kaiparathinini** is introduced.

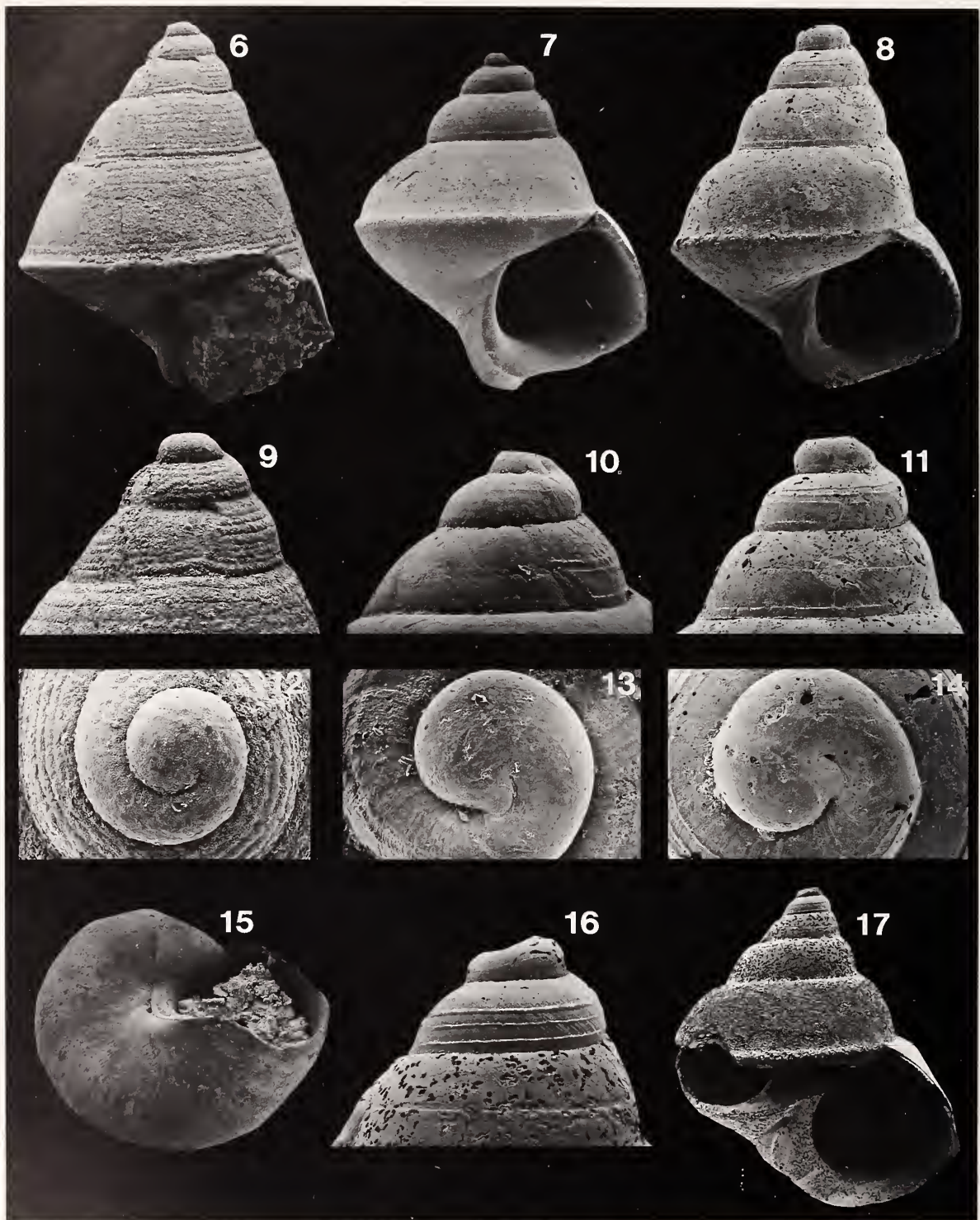
Intestinal tracts of specimens of *Kaiparathina boucheti* contain much fine, white matter of unknown origin together with numerous minute, silicious sponge spicules, predominantly tetraxonic. That these spicules are the remains of prey rather than incidentally ingested components of detritus is suggested not only by their quantity but also by the large size and morphology of the central radular tooth, which seems to be ideally suited for prey penetration and slicing rather than for detritivory or deposit feeding. Sponge feeding is rare among Trochoidea and is known only in a few species of Calliostomatidae (summarized by MARSHALL, 1988) and in at least some of the Trochaclididae (HAIN, 1990; HICKMAN & MCLEAN, 1990; personal observations).

The anterolateral fields on the sides of the foot are a radical departure from the standard trochoidean plan and are clearly apomorphic (Figures 1–3, 5). Their function is unknown.



Explanation of Figures 1 to 5

Figures 1–5. *Kaiparathina boucheti* Marshall, sp. nov. Critical-point dried animal (retracted, unfixed, *ex alcohol*), MUSORSTOM 4 sta. DW221. Figures 1–2. Head-foot, subject length 4.8 mm; note prominent propodial horns inclined to animal's left in Figure 1. Figure 3. Detail of tip of right cephalic tentacle and ventral margin of right anterolateral structure. Figure 4. Detail of dorsal surface of right cephalic tentacle (right) and tentaculiform processes at snout edge. Figure 5. Detail of right anterolateral structure showing granulate surface. als, anterolateral structure; ct, cephalic tentacle; es, eyestalk; et, epipodial tentacle; fo, foot; op, operculum; sn, snout. Scales = 100  $\mu$ m.



## Explanation of Figures 6 to 17

Figures 6–17. *Kaiparathina* species.

Figures 6, 9, 12. *K. senex* Marshall, sp. nov., holotype, Late Paleocene-Early Eocene, Pitt Island, Chatham Islands, New Zealand, shell height 3.90 mm. Detail width in Figure 9 = 1.60 mm, Figure 12 = 970  $\mu$ m.

Figures 7, 10, 13, 15. *K. praecellens* Laws, 1941, Early Miocene, Pakaurangi Point, Kaipara Harbour, New

Genus *Kaiparathina* Laws, 1941

*Kaiparathina* LAWS, 1941:145. Type species (by original designation): *Kaiparathina praecellens* Laws, 1941; Early Miocene, Pakaurangi Point, Kaipara Harbour, New Zealand.

Diagnosis and Description as for *Kaiparathinini*.*Kaiparathina praecellens* Laws, 1941

(Figures 7, 10, 13, 15)

*Kaiparathina praecellens* LAWS, 1941:145, pl. 19, fig. 38; FLEMING, 1966:49; JONES, 1970:164; BEU, 1973:320, figs. 19, 20; BEU & MAXWELL, 1990:404.

**Type data:** Holotype NZGS TM 1400: Pakaurangi Point, Kaipara Harbour, New Zealand; Otaian (Early Miocene).

**Other material examined:** (7 specimens MNZ, 10 NZGS). Tuffaceous siltstone, small bay ca. 1.6 km NW of Pakaurangi Point, Kaipara Harbour, New Zealand, map ref. Q8/262513 (f 9828), March 1979, B. A. Marshall and P. A. Maxwell; Otaian (Early Miocene).

**Distribution:** Early Miocene (Otaian), Pakaurangi Point, Kaipara Harbour, northern New Zealand.

**Remarks:** As noted by LAWS (1941) some specimens retain traces of the original color pattern, which is evidently restricted to the last adult whorl; it comprises wavy axial lines that extend abapically from about midway between the suture and periphery and across the base. The lines are gently opisthocline on the spire, and so strongly opisthocline as to be almost spiral on the base. A somewhat similar color pattern is exhibited by *Kaiparathina navakaensis* (Ladd, 1982) and *K. vaubani* sp. nov. (Figure 27). JONES (1970) concluded that beds containing *K. praecellens* were deposited in a warm sea at up to about 250 m depth.

*Kaiparathina senex* Marshall, sp. nov.

(Figures 6, 9, 12)

**Description:** Shell (holotype) 3.90 mm high, higher than broad, spire 1.5× as high as aperture, of moderate thickness, anomphalous.

Protoconch 430 μm wide, surface etched away.

Teleoconch of 4.4 whorls. First 1.5 whorls evenly convex, subsequent whorls weakly convex, periphery angulate, base more or less flat. First whorl with 5 rounded, closely spaced spiral cords, multiplying to 10 on subsequent whorls, peripheral spiral strongest, rounded, others broad

and flattened with sublinear interspaces. Base with 15 similar, rounded spiral cords with interspaces about as wide as each spiral. Collabral growth lines prosocline on spire, sigmoidal on base. Aperture subquadrate, outer lip thin, inner lip thick.

**Type data:** Holotypes NZGS TM 7301, GS 12159 (CH/f471), Coarse Red Bluff Tuff on large wave-cut platform and in low outcrops at base of cliff below Pliocene section on cliff due north of The Bluff homestead (grid ref. NZMS 260/234712), Pitt Island, Chatham Islands, New Zealand, Jan. 1977, A. G. Beu, P. A. Maxwell and H. J. Campbell: Late Teurian-Early Waipawan (Late Paleocene-Early Eocene).

**Distribution:** Late Paleocene-Early Eocene (Late Teurian-Early Waipawan), Pitt Island, Chatham Islands, New Zealand.

**Remarks:** *Kaiparathina senex* differs from all other species of *Kaiparathina* by having a larger protoconch, and more numerous and persistent spiral cords on the spire. *Kaiparathina daedala* sp. nov. has a similar number of weaker spiral cords on the base.

According to BEU & MAXWELL (1990:88) the Red Bluff Tuff faunules inhabited a hard substratum on the summits or flanks of volcanic sea-mounts in an oceanic environment, probably at outer shelf or bathyal depths.

**Etymology:** Old (Latin).

*Kaiparathina navakaensis* (Ladd, 1982)

(Figures 8, 11, 14, 27; Table 1)

*Calliotrochus navakaensis* LADD, 1982:24, pl. 34, figs. 9–11.

**Type data:** Holotype, USNM 214405: United States Geological Survey loc. 24198, Navaka River, Santo, Vanuatu; Pleistocene.

**Other material examined:** 1 topotype USNM.

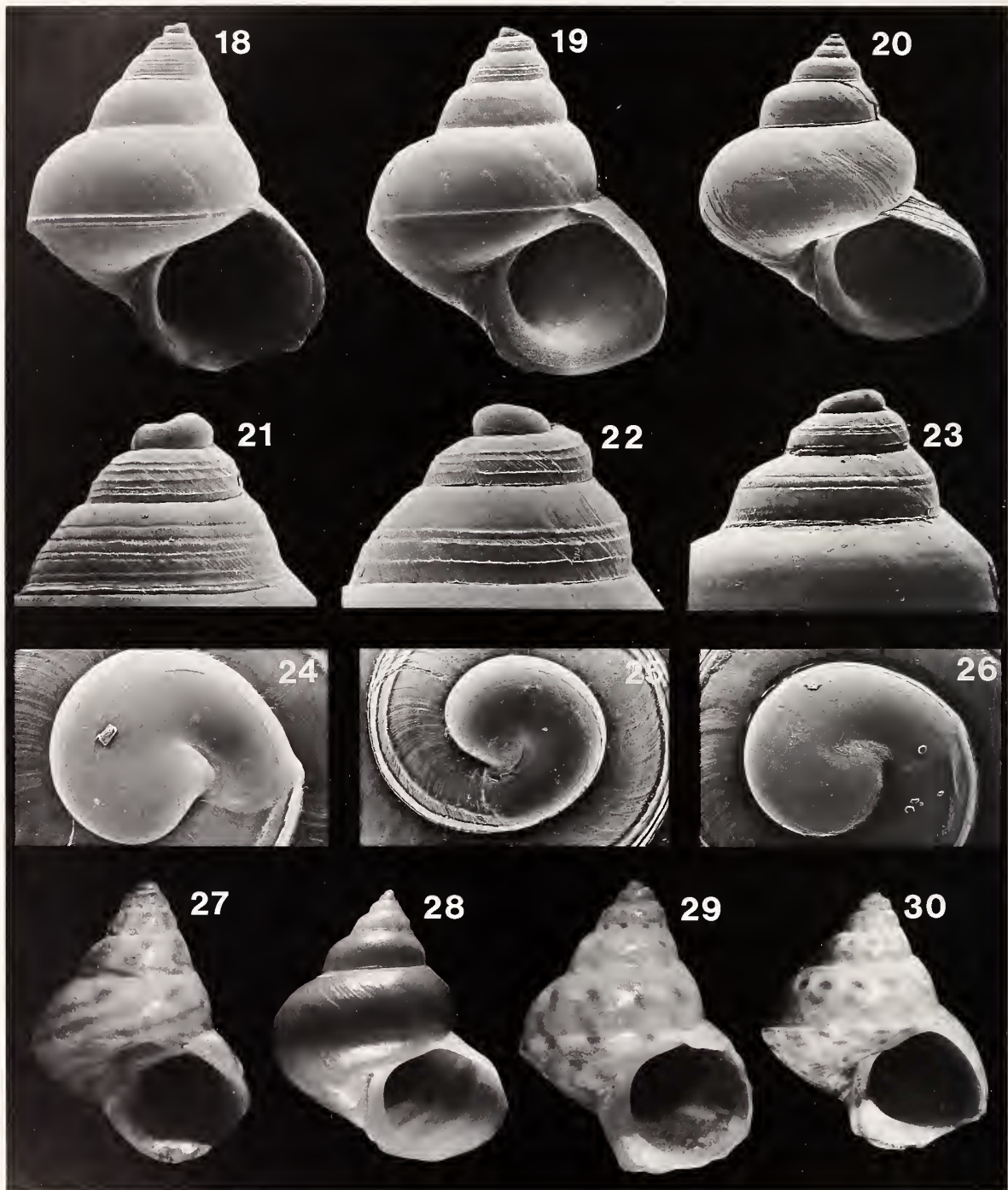
**Distribution:** Pleistocene, Santo, Vanuatu.

**Remarks:** Although originally referred to the genus *Calliotrochus* Fischer, 1879 (type species *Turbo phasianellus* Deshayes, 1863), Ladd's species clearly belongs in *Kaiparathina*. The type species of *Calliotrochus* (DESHAYES, 1863:pl. 36, figs. 13, 14; WENZ, 1938:fig. 620) differs markedly in shell facies and the genus apparently belongs in subfamily Trochinae, tribe Gibbulini (HICKMAN & MCLEAN, 1990). From the Recent species described here-

Zealand, NZGS TM 7303. Figure 7. Shell height 2.30 mm. Detail width in Figure 10 = 900 μm, Figure 13 = 470 μm, Figure 15 shell width = 3.20 mm.

Figures 8, 11, 14. *K. navakaensis* Ladd, 1982, Pleistocene, Santo, Vanuatu, USNM 459658, shell height 2.05 mm. Detail width Figure 11 = 950 μm, Figure 14 = 480 μm.

Figures 16, 17. *K.* sp. cf. *navakaensis* Ladd, 1982, MUSORSTOM 6 sta. DW410, off Lifou, Loyalty Islands, 490 m, MNHN, shell height 5.00 mm. Detail width in Figure 16 = 1.30 mm.



Explanation of Figures 18 to 30

Figures 18–30. *Kaiparathina* species.

Figures 18, 21, 24. *K. boucheti* Marshall, sp. nov., holotype, BIOCAL sta. DW46, off southern New Caledonia, 570–610 m, shell height 5.45 mm. Detail width in Figure 21 = 1.60 mm, Figure 24 = 530  $\mu$ m.

Figures 19, 22, 25. *K. vaubani* Marshall, sp. nov., holotype, MUSORSTOM 4 sta. DW164, off northern New Caledonia, 255 m, shell height 3.70 mm. Detail width in Figure 22 = 1.00 mm, Figure 25 = 500  $\mu$ m.

Figures 20, 23, 26, 28. *K. coriolis* Marshall, sp. nov., holotype, MUSORSTOM 5 sta. 309, Nova Bank, northern Lord Howe Rise, 340 m, shell height 10.1 mm. Detail width in Figure 23 = 1.70 mm, Figure 26 = 500  $\mu$ m.

Table 1

*Kaiparathina navakaensis* and *K. sp. cf. navakaensis*. Shell measurements (mm) and countings.

Height	Diameter	Height/ diameter	Teleoconch whorls	Material
5.00	4.90	1.02	4.60	DW410
4.90	4.40	1.11	4.75	DW410
3.90	3.25	1.20	4.60	Holotype
2.95	2.75	1.07	3.70	DW08
2.05	1.75	1.17	3.50	Paratype

in, the holotype of *K. navakaensis* is distinguished by its very thick shell, the weakly convex 2nd–4th teleoconch whorls, and the color pattern of dark, strongly opisthocline bands that are continuous across the spire and base. A topotype (Figures 8, 11, 14) resembles the holotype in shell thickness and sculpture, but differs by having a smaller protoconch (width 330  $\mu\text{m}$  instead of 370  $\mu\text{m}$ ) and less markedly flattened teleoconch whorls. The specific status of this topotype cannot be resolved with such limited material, and it is only tentatively interpreted as *K. navakaensis*.

*Kaiparathina navakaensis* may still be living off Vanuatu, and perhaps off the Loyalty Islands as well (see below).

*Kaiparathina sp. cf. navakaensis* (Ladd, 1982)

(Figures 16, 17; Table 1)

**Material examined:** (3 specimens MNHN): BIOCAL sta. DW08, 20°34'S, 166°54'E, off Lifou, Loyalty Is., dead, 435 m, n.o. *Jean-Charcot* (1); MUSORSTOM 6 sta. DW410, 20°38'S, 167°07'E, off Lifou, dead, 490 m, n.o. *Alis* (2).

**Remarks:** Three specimens dredged off Lifou, Loyalty Islands closely resemble the holotype of *Kaiparathina navakaensis* (Figure 27) in shell shape, sculpture, and thickness. They differ primarily by having slightly broader protoconchs (width 400  $\mu\text{m}$  instead of 370  $\mu\text{m}$  holotype and 330  $\mu\text{m}$  in topotype). Although all three are bleached and etched to some extent, the late teleoconch whorls of the two shells from station DW410 have a pale, dull, pinkish flush, and one has darker peripheral blotches. Additional, better preserved material from both Vanuatu and the Loyalty Islands will be required to ascertain the specific status of this form.

*Kaiparathina sp. cf. navakaensis* and *K. boucheti* occurred together as shells at station DW08.

Table 2

*Kaiparathina boucheti* Marshall, sp. nov. Shell measurements (mm) and countings.

Height	Diameter	Height/ diameter	Teleoconch whorls	Material
6.30	6.10	1.03	4.60	Paratype DW221
5.90	5.40	1.09	4.80	Paratype DW221
5.45	4.75	1.15	4.50	Holotype DW46
4.85	4.20	1.15	4.30	Paratype DW46
4.65	4.05	1.15	4.30	Paratype DW46
4.10	3.55	1.15	4.10	Paratype DW46

*Kaiparathina boucheti* Marshall, sp. nov.

(Figures 1–5, 18, 21, 24, 39–44; Table 2)

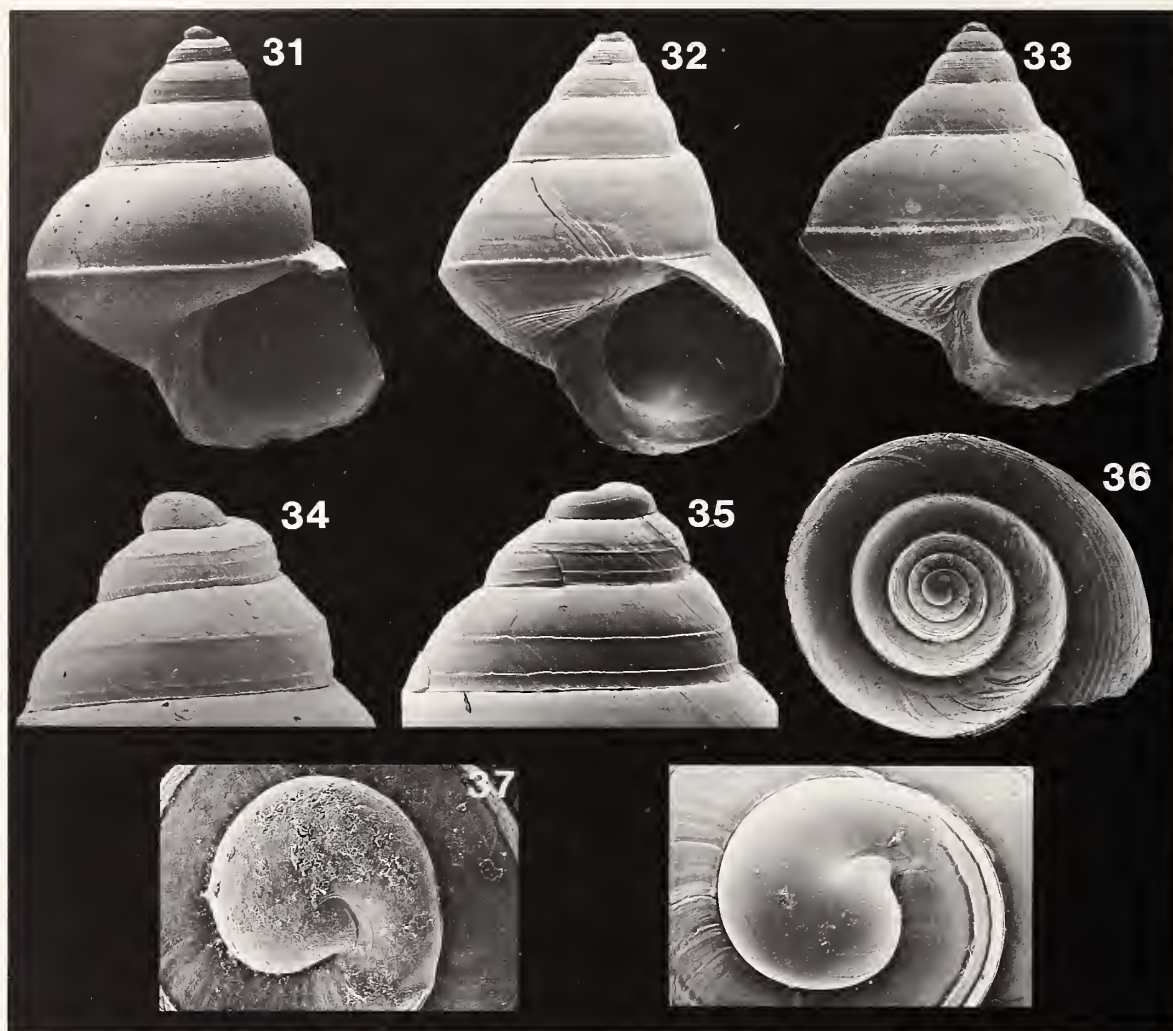
**Description:** Shell up to 6.30 mm high, slightly higher than broad, spire about as high as aperture, thin, translucent, glossy, anomphalous. Protoconch reddish brown. Start of 1st teleoconch whorl reddish brown, rapidly fading, uniformly nacreous through colorless outer shell layer after 1st 0.5–0.75 whorl.

Protoconch 400–420  $\mu\text{m}$  wide, with 4 fine, crisp, widely spaced spiral threads.

Teleoconch of up to 4.8 convex whorls, periphery weakly angulate, base gently rounded. First 2 whorls with crisp spiral threads that multiply by intercalation, spirals absent from adapical quarter, abapical (peripheral) threads persisting throughout, others weakening and vanishing on third whorl; spiral threads numbering 3 or 4 at start of 1st whorl, multiplying to 6–8, narrow with broader interspaces on 1st whorl, after which broader with considerably narrower interspaces; abapical spiral gradually enlarging to form rounded peripheral spiral cord. Base with or without 1 or 2 spiral threads close beside peripheral spiral and columella; obscure spiral lines throughout. Aperture subcircular, outer lip thin, inner lip thick, parietal glaze very thin. Collabral growth lines prosocline on spire, sigmoidal on base.

Animal (Figures 1–5) milky white. Snout tip broadly expanded, with prominent papillate processes. Cephalic tentacles large, dorsoventrally flattened, tapered, minutely and densely papillate, large eyes at tips of swollen outer basal eyestalks; neck lobes thin, not digitate, right considerably larger than left; epipodial tentacles of moderate size, minutely and densely papillate, 3 on each side; no cephalic lappets; large, swollen, clearly demarcated anterolateral structures between epipodial fringe and sole; foot large,

Figures 27–30. Photographs of uncoated shells to show color patterns. Figure 27. *K. navakaensis*, Ladd, 1982, holotype, shell height 3.90 mm. Figure 28. *K. coriolis* Marshall, sp. nov., holotype, shell height 10.1 mm. Figure 29. *K. fasciata* Marshall, sp. nov., holotype, shell height 3.35 mm. Figure 30. *K. daedala* Marshall, sp. nov., paratype (MNHN), shell height 4.05 mm.



Explanation of Figures 31 to 38

Figures 31–38. *Kaiparathina* species.

Figures 31, 34, 37. *Kaiparathina fasciata* Marshall, sp. nov., holotype, Wanganella Bank, southern Norfolk Ridge, 133 m, shell height 3.35 mm. Detail width in Figure 34 = 1.00 mm, Figure 37 = 460  $\mu$ m.

Figures 32, 33, 35, 36, 38. *Kaiparathina daedala* Marshall, sp. nov. Figures 32, 35, 38. Holotype, off Réunion, 210–227 m, shell height 4.65 mm. Detail width in Figure 35 = 1.40 mm, Figure 38 = 470  $\mu$ m. Figures 33, 36. Paratype (MNHN), off Réunion, 280–340 m, shell height 4.05 mm, width 3.80 mm.

elongate, with prominent anterior horns, posteriorly tapered. Operculum rather thin, chitinous, multispiral, growing edge short.

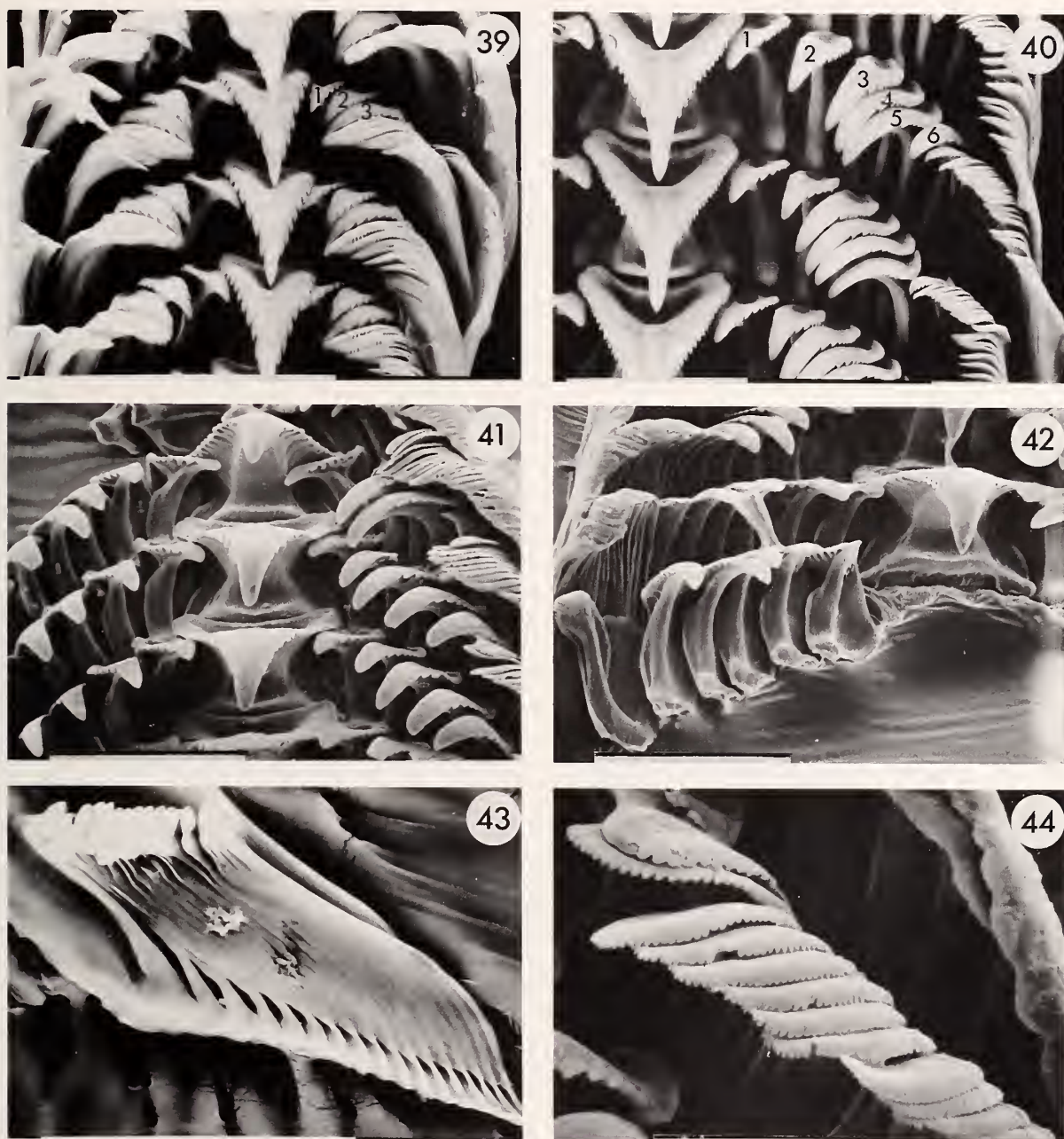
Radula (Figures 39–44) with the formula  $\infty + 6 + 1 + 6 + \infty$ . Central tooth large, very stoutly built, about as long as broad; cutting area narrowly angulate, strongly hooked, laterally flanged, edges finely serrate; terminal cusp large, slender; shaft face strongly thickened, back concave; base laterally flanged to interlock with lateral teeth. Lateral teeth progressively multiplying to 6 pairs by in-column transformation of marginals, longer than broad, elongating outwards, stout; cutting areas laterally flanged, narrowly tapered, finely serrate, terminal cusp large; shaft face strongly thickened, outer edge modestly flanged and

inner edge very strongly flanged to interlock with adjacent teeth. Marginal teeth numerous; outermost tooth broad and laminar, inner teeth slender, tips blunt, finely serrate, shafts of all but innermost and outermost teeth incompletely separated.

Jaw plates like those in *Kaiparathina coriolis* and *K. daedala* (see below).

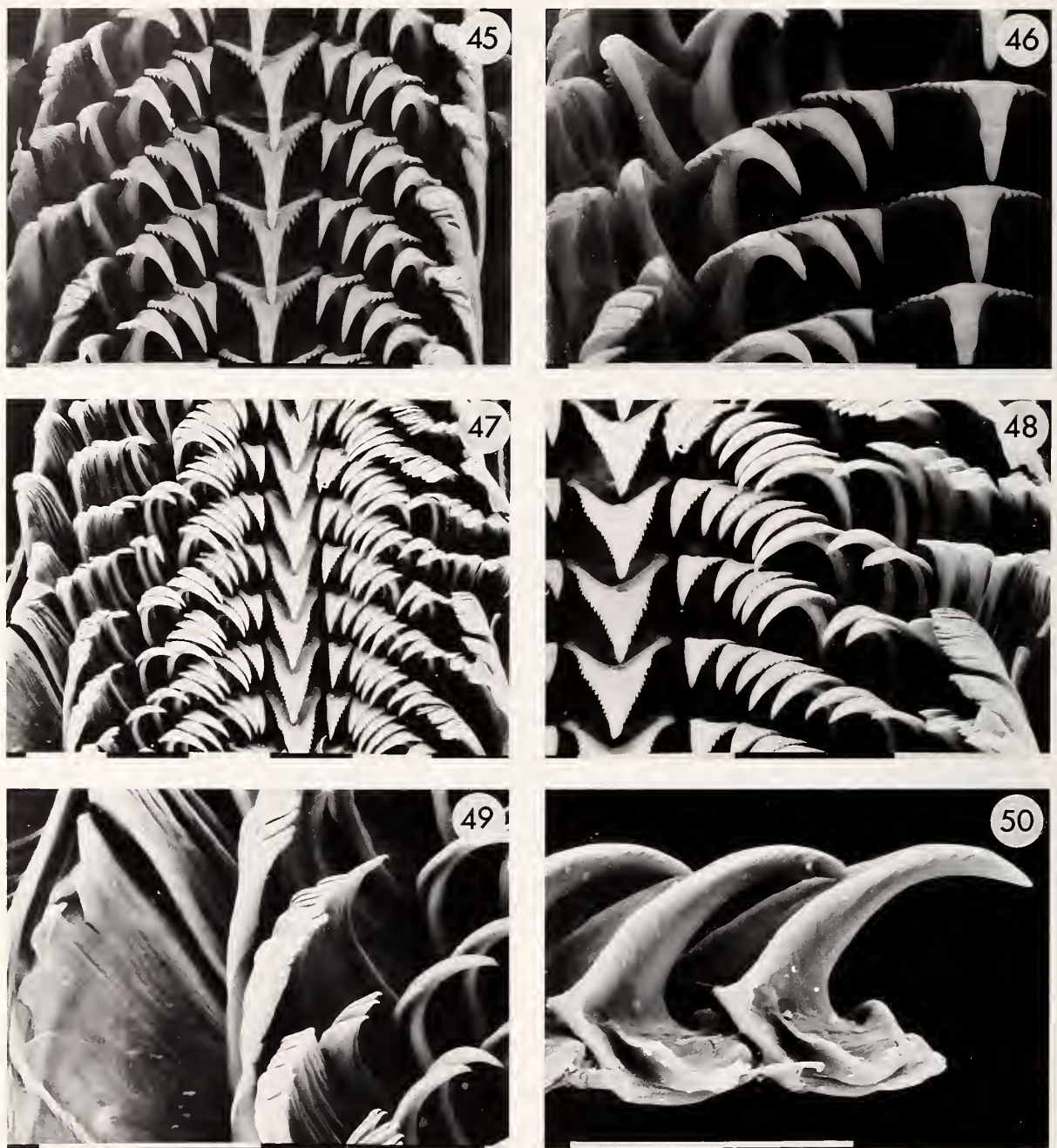
**Type material:** Holotype MNHN, and 4 paratypes (3 MNHN, 1 MNZ): BIOCAL sta. DW46, 22°53'S, 167°17'E, off S New Caledonia, alive, 570–610 m, n.o. *Jean-Charcot*. Paratypes (39): MUSORSTOM 4 sta. DW 151, 19°07'S, 163°22'E, dead, 200 m, n.o. *Vauban* (1 MNHN); BIOCAL sta. DW08, 20°54'S, 166°54'E, dead,





Explanation of Figures 39 to 44

Figures 39–44. *Kaiparathina boucheti* Marshall, sp. nov., radulae. Figure 39. Entire width of radula from juvenile paratype, shell height 2.60 mm, showing 3 pairs of lateral teeth, MUSORSTOM 4 sta. DW221 (MNHN). Figure 40. Part width of radula from adult paratype, shell height 3.65 mm, showing 6 pairs of lateral teeth, MUSORSTOM 4 sta. DW221 (MNHN). Figures 41, 42, 44. Radula *ex* holotype. Figures 41, 42. Details of central and lateral teeth; note laterally flanged cutting areas, massive central tooth, and strongly laterally flanged shafts of lateral teeth. Figure 43. Bank of marginal teeth (lacking outermost tooth at right) from radula illustrated in Figure 44. Figure 44. Tips of inner marginal teeth. Scales Figures 39–43 = 100  $\mu$ m, Figure 44 = 25  $\mu$ m.



## Explanation of Figures 45 to 50

Figures 45, 46. *Kaiparathina vaubani* Marshall, sp. nov., holotype radula. Figure 45. Entire width. Figure 46. Detail of central (right) and lateral teeth.

Figures 47-50. *Kaiparathina coriolis* Marshall, sp. nov., holotype radula. Figure 47. Entire width. Figure 48. Detail of central and lateral teeth. Figure 49. Detail of outermost lateral (right) and marginal teeth; note broad outermost marginal at lower left and incomplete separation of shafts of teeth above it. Figure 50. Side view of isolated column of central teeth showing the huge cutting area and short basal plate with interlocking lateral flanges and strong median boss. Scales = 100  $\mu$ m.

435 m, n.o. *Jean-Charcot* (8 MNHN); BIOCAL sta. DW 83, 20°35'S, 166°54'E, dead, 460 m, n.o. *Jean-Charcot* (1 MNHN); BIOGEOCAL sta. DW307, 20°35'S, 166°55'E, dead, 470–480 m, n.o. *Coriolis* (1 MNHN); BIOCAL sta. KG 06, 20°36'S, 166°53'E, dead, 735 m, n.o. *Jean-Charcot* (1 MNHN); MUSORSTOM 4 sta. DW225, 22°52'S, 167°23'E, dead, 590–600 m, n.o. *Vauban* (1 MNHN); BIOCAL sta. CP 40, 22°55'S, 167°24'E, dead, 650 m, n.o. *Jean-Charcot* (1 MNHN); MUSORSTOM 4 sta. DW222, 22°56'S, 167°33'E, alive, 410–440 m, n.o. *Vauban* (2 MNHN); MUSORSTOM 4 sta. DW221, 22°59'S, 167°37'E, alive, 535–650 m, n.o. *Vauban* (25: 1 AMS, 1 BMNH, 19 MNHN, 2 MNZ, 1 NMP, 1 USNM); SMIB 4 sta. DW61, 23°00'S, 167°22'E, alive, 520–550 m, n.o. *Alis* (1 MNHN); BIOCAL sta. DW56, 23°35'S, 167°12'E, dead, 695–705 m, n.o. *Jean-Charcot* (1 MNHN).

**Distribution:** Off northern and southern New Caledonia and northern Norfolk Ridge, 200–735 m, living at 410–610 m.

**Remarks:** *Kaiparathina boucheti* differs from *K. praeclans* and *K. navakaensis* by having a thinner shell, a larger protoconch, and more strongly convex teleoconch whorls. *Kaiparathina boucheti* differs further by being more strongly and extensively sculptured on the early teleoconch whorls, by constantly lacking a color pattern, and by being larger relative to the number of whorls (Tables 1, 2).

**Etymology:** Named after Philippe Bouchet (MNHN).

*Kaiparathina vaubani* Marshall, sp. nov.

(Figures 19, 22, 25, 45, 46; Table 3)

**Description:** Shell up to 4.5 mm high, higher than broad, spire about as high as aperture, stout, glossy, anomphalous. Protoconch pinkish to blackish brown. First whorl chocolate on adapical half, or 1st half whorl with pinkish subsutural zone, elsewhere translucent white. Subsequent whorls translucent white, internal nacreous layer showing through thin outer shell layers, with or without narrow, dull pink, opisthocline axial bands on 3rd whorl only, or on 3rd and subsequent whorls, including base. Inner lip white.

Protoconch 330  $\mu$ m wide, with 3 fine, crisp spiral threads, otherwise smooth.

Teleoconch of up to 4.75 convex whorls, periphery broadly rounded at maturity, weakly angulate before, base weakly convex. Peripheral keel narrow, rounded, adapical margin shelved and exposed on spire. First 2 spire whorls with 3 similar, narrow, rounded spiral threads on abapical half, their adapical margins sharply shelved, becoming obsolete at end of 2nd whorl. Subsequent whorls smooth apart from obscure spiral and collabral growth lines. Base with a spiral thread beside inner lip. Collabral growth lines prosocline, very weakly sigmoidal on spire, more deeply sigmoidal on base. Aperture subcircular, peristome

Table 3

*Kaiparathina vaubani* Marshall, sp. nov. Shell measurements (mm) and countings.

Height	Diameter	Height/ diameter	Teleoconch whorls	Material
4.50	3.95	1.14	4.75	Paratype CC175
4.00	3.60	1.11	4.25	Paratype CC175
3.85	3.50	1.10	4.20	Paratype DW38
3.70	3.30	1.12	4.25	Holotype DW164
2.60	2.45	1.06	3.20	Paratype DW38

discontinuous; outer lip thin at rim, thicker and simple within; inner lip thick, parietal gaze very thin.

Animal white, as in *Kaiparathina boucheti* but with longer, more narrowly tapered epipodial tentacles. Operculum as in *K. boucheti*. Jaw as in *K. coriolis* and *K. daedala*.

Radula (Figures 45, 46) similar to that of *Kaiparathina boucheti* but with 4 lateral teeth, a much longer terminal cusp on central tooth, and sharper cusps on lateral teeth.

**Type data:** Holotype MNHN: MUSORSTOM 4 sta. DW164, 18°33'S, 163°13'E, off d'Entrecasteux Reefs, N New Caledonia, alive, 255 m, n.o. *Vauban*. Paratypes (2): MUSORSTOM 4 sta. CC 175, 18°59'S, 163°17'E, off Grande Récif de Cook, N New Caledonia, dead, 355 m, n.o. *Vauban* (1 MNHN, 1 MNZ).

**Other material examined:** (2 specimens MNHN): BIOCAL sta. DW38, 23°00'S, 167°15'E, off Grand Récif du Sud, S New Caledonia, dead, 360 m, n.o. *Jean-Charcot*.

**Distribution:** Northern and southern New Caledonia, 255–360 m, living at 255 m.

**Remarks:** *Kaiparathina vaubani* differs from *K. navakaensis* and *K. sp. cf. navakaensis* by having a substantially thinner shell, slightly but distinctly stronger sculpture on the first teleoconch whorl, and more strongly convex teleoconch whorls. Some specimens, including the holotype, resemble the holotype of *K. navakaensis* in color pattern, but the color bands in *K. vaubani* are narrower. It differs from *K. boucheti* by having a thicker shell, a smaller protoconch, by usually having axial color bands, and in details of radular morphology.

**Etymology:** Named after n.o. *Vauban*, with which the type material was obtained.

*Kaiparathina coriolis* Marshall, sp. nov.

(Figures 20, 23, 26, 28, 47–50, 55, 56; Table 4)

**Description:** Shell up to 10.1 mm high, slightly higher than broad, spire 0.74 (subadult) to 1.20 $\times$  as high as aperture, stout, glossy, a narrow crescentic umbilical chink

Table 4

*Kaiparathina coriolis* Marshall, sp. nov. Shell measurements (mm) and countings.

Height	Diameter	Height/ diameter	Teleoconch whorls	Material
10.1	9.40	1.07	5.50	Holotype
9.60	8.80	1.09	5.50	Paratype
8.20	8.10	1.01	5.10	Paratype

at maturity. Protoconch white. Teleoconch buff to pale pinkish buff, suprmedian spiral on 1st 3 whorls and exposed part of peripheral keel on 1st 3.5 whorls alternately spotted white and reddish brown. Inner lip and base close beside it white, interior nacreous.

Protoconch 400  $\mu\text{m}$  wide, 2 fine crisp spiral threads, otherwise essentially smooth.

Teleoconch of up to 5.5 strongly convex whorls; periphery evenly rounded at maturity, weakly angulate before; base weakly convex. Peripheral keel rounded, almost entirely exposed on spire, becoming obsolete late on 5th whorl. Early whorls with rounded suprmedian and suprasutural spiral threads, the latter close beside peripheral keel. Suprmedian spiral becoming obsolete late on 3rd whorl, narrow at first, gradually widening, bounded by grooves; adapical groove narrow throughout; abapical groove as broad as thread on 1st whorl, then progressively infilled by widening spiral thread. Suprasutural spiral bounded adapically by fine groove, becoming obsolete late on 2nd whorl. Elsewhere smooth apart from fine collabral growth lines, prosocline and shallowly sigmoidal on spire, more deeply sigmoidal on base. Aperture subcircular; outer lip thin at rim, thicker and simple within; inner lip thick, parietal glaze thin.

Animal creamy white. Head broad, dorsoventrally flattened. Snout tip concave in front, fringed with prominent, finely and densely papillate projections. Cephalic tentacles tapered, dorsoventrally flattened, minutely and densely papillate, well-developed eyes in prominent eyestalks at outer bases. Neck lobe on right considerably longer than broad, thin, extending from base of eyestalk, none on left. Epipodial fringe prominent, 1 tapered epipodial tentacle on either side, 1 or 2 smaller tentacles on each side of opercular lobe. Anterolateral fields very large, clearly delineated. Foot longer than broad, anteriorly indented between prominent, tapered lateral horns. Operculum thin, chitinous, multispiral.

Jaws (Figures 55, 56) thin, subrectangular with rounded corners, elements minute.

Radula (Figures 47–50) with the formula  $\infty + 9 + 1 + 9 + \infty$ , 40 cross rows, teeth longer than broad. Central tooth relatively large, stout; cutting area large, laterally flanged, narrowly angulate, curved, sharply serrate; shaft face strongly thickened, shaft back concave; base flanged and grooved to interlock with laterals. Lateral teeth con-

siderably narrower than central; cutting areas narrowly angulate, outer edges laterally flanged and sharply serrate; shaft faces thickened, basal edges flanged and grooved to interlock with adjacent teeth. Marginal teeth slender, cutting areas rounded, leading edges finely serrate, shafts of all but innermost and outermost teeth incompletely separated, outermost few pairs with very broad laminar shafts and smooth tips; innermost tooth morphologically intermediate between inner laterals and outer marginals.

**Type material:** Holotype and paratype MNHN, paratype MNZ: MUSORSTOM 5 sta. 309, 22°10'S, 159°23'E, Nova Bank, alive, 340 m, n.o. *Coriolis*.

**Distribution:** Nova Bank, northern Lord Howe Rise, 340 m.

**Remarks:** *Kaiparathina coriolis* differs from other species of *Kaiparathina* by attaining much larger size, and by details of teleoconch microsculpture, color, and color pattern. It differs further from *K. boucheti* and *K. vaubani* by having more numerous lateral teeth and by details of tooth morphology, particularly the presence of a relatively much smaller terminal cusp on the central tooth.

**Etymology:** After n.o. *Coriolis*.

*Kaiparathina fasciata* Marshall, sp. nov.

(Figures 29, 31, 34, 37)

**Description:** Shell (holotype) 3.35 mm high, slightly higher than broad, spire evenly conical, 1.05  $\times$  height of aperture, anomphalous, thin, translucent, glossy, nacreous through thin outer shell layer. Purplish brown beside suture on protoconch and first 0.25 teleoconch whorl. Subsequent whorls with median and peripheral bands of opaque white that are regularly interrupted by V-shaped, spirally dislocated axial bands of yellowish brown, axial bands extending as irregular zigzags across base. Columella opaque white.

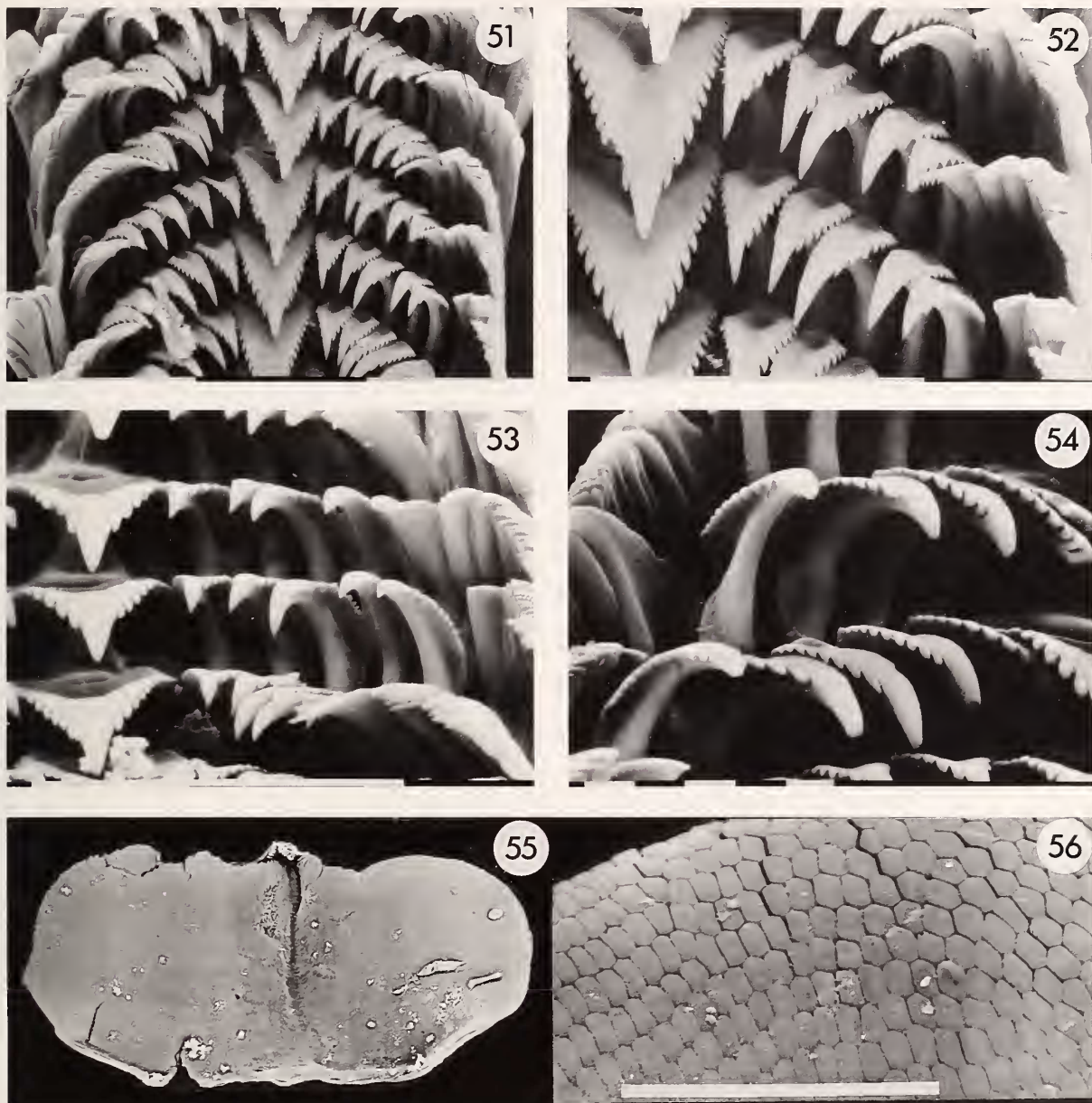
Protoconch 320  $\mu\text{m}$  wide, sculptured with few fine, crisp spiral threads.

Teleoconch of 4.25 convex whorls, periphery subangulate, base gently rounded. First 1.75 whorls with 4 fine, crisp spiral threads on abapical half, abapical spiral bordering suture and persisting throughout, others progressively weakening and vanishing, the last vanishing at end of 2nd whorl. Three fine spiral threads on outside of columella. Columella thick, vertical. Aperture subcircular. Outer lip thin, inner lip thick, parietal glaze thin. Collabral growth lines prosocline on spire, sigmoidal on base.

Animal unknown.

**Type data:** Holotype MNZ M.247716 (3.35  $\times$  2.75 mm, 4.25 teleoconch whorls) and juvenile paratype MNZ: BS 884 (0.630), 32°32.6'S, 167°29.2'E, summit of Wanganella Bank, Norfolk Ridge, dead, 133 m, r.v. *Tangaroa*.

**Distribution:** Wanganella Bank, southern Norfolk Ridge, 133 m (dead).



## Explanation of Figures 51 to 56

Figures 51–54. *Kaiparathina daedala* Marshall, sp. nov., holotype radula. Figure 51. Entire width. Figures 52–54. Details of central and lateral teeth.

Figures 55, 56. *Kaiparathina coriolis* Marshall, sp. nov., holotype jaw, ventral (interior) surface, anterior edge at top. Figure 55. Jaw width 1.60 mm. Figure 56. Detail of jaw elements of anterior edge. Scale Figures 51, 52, 53, 56 = 100  $\mu$ m, Figure 54 = 25  $\mu$ m.

**Remarks:** *Kaiparathina fasciata* differs from the holotype of *K. navakaensis* by being much thinner-shelled, by having a more exsert protoconch and slightly, but distinctly, more strongly convex whorls, and by color pattern. It differs from *K. boucheti* by having a substantially smaller protoconch (width 320  $\mu$ m instead of 400–420  $\mu$ m), by being more weakly and sparsely sculptured, and by having a

color pattern on the teleconch. It differs from *K. prae-cellens* by being thinner-shelled, more narrowly conical, and smaller in size relative to the number of whorls. *Kaiparathina fasciata* is substantially smaller than *K. coriolis*, which also differs in details of sculpture, color and color pattern.

**Etymology:** Banded (Latin).

*Kaiparathina daedala* Marshall, sp. nov.

(Figures 30, 32, 33, 35, 36, 38, 40, 41, 51–54)

**Description:** Shell up to 4.65 mm high, usually higher than broad, spire 0.9–1.2× as high as aperture, anomphalous, of moderate thickness, glossy, nacreous within. Protoconch tip purplish brown. Teleoconch color variable. Holotype: first 2 whorls translucent white, subsequent spire whorls and base pinkish buff with narrow supra- and subsutural bands; suprasutural band (on peripheral keel) of reddish brown spots, subsutural band white; scattered reddish brown spots on base. Paratype with supra- median and suprasutural (on peripheral keel) rows of pinkish gray spots, ground color predominantly white over adapical half of whorl and pale pinkish gray below and on base, the latter mottled in paler and darker shades. Inner lip white, rim darkly pigmented.

Protoconch 370 μm wide, sculptured with 3 fine, crisp spiral threads, otherwise smooth.

Teleoconch of up to 4.7 convex whorls; periphery becoming rounded on last adult whorl, broadly angulate before; base weakly convex. First 2 spire whorls sculptured with 4 rounded spiral threads that may multiply by intercalation to number 6, adapical margins sharply defined; abapical spiral becoming strongest, persisting as peripheral keel, adapical margin exposed on spire; other spirals weakening late on 2nd whorl and vanishing early on 3rd whorl, spiral bordering peripheral spiral sometimes (paratype) persisting throughout. Subsequent whorls smooth apart from obscure spiral lines, and collabral growth lines; in paratype, however, 13 similar, rounded spiral threads resolve on last half of last adult whorl. Base with 14–16 rounded spiral threads, most of those on outer third resolving on last half of last adult whorl. Collabral growth lines shallowly sigmoidal on spire, more deeply sigmoidal on base. Aperture subquadrate; outer lip thin at rim, thicker and simple within; inner lip thick, parietal glaze very thin.

Animal (reconstituted): operculum and jaws similar to those of *Kaiparathina boucheti* and *K. coriolis*.

Radula (Figures 51–54). Central tooth similar to that in *Kaiparathina coriolis*, lateral (5 pairs) and marginal teeth similar to those in *K. vaubani*.

**Type data:** Holotype MNHN (4.65 × 3.80 mm, 4.70 teleoconch whorls), *Marion-Dufresne* cruise 32 sta. CP57, 21°05'S, 55°11'E, off Réunion, alive, 210–227 m. Paratype MNHN (4.05 × 3.80 mm, 4.30 teleoconch whorls), *Marion-Dufresne* cruise 32 sta. DC 128, 20°51'S, 55°36'E, off Réunion, dead, 280–340 m.

**Distribution:** Off Réunion, 210–340 m, living at 210–227 m.

**Remarks:** *Kaiparathina daedala* is distinctive in having numerous spiral threads on the base. The terminal cusp of the central tooth is small as in *K. coriolis* instead of stiletto-like as in *K. boucheti* and *K. vaubani*.

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